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17 April 1984

# USSR Report

## ENGINEERING AND EQUIPMENT

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# USSR REPORT

## ENGINEERING AND EQUIPMENT

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UDC 621.01

# FEASIBILITY ANALYSIS OF NOVEL TECHNOLOGICAL PRINCIPLES OF PRODUCING MULTICOMPONENT MECHANISMS

Moscow MASHINOVEDENIYE in Russian No 5, Sep-Oct 83
(manuscript received 2 Feb 82) pp 56-63

LYMZIN, V. N. and ROSTOVTSEV, A. M., Moscow

[Abstract] Structural analysis of technological processes by the graph method and based on the concept of "technological" state is applied to a feasibility study of novel principles of producing multicomponent mechanisms for accurate performance under operating conditions. A technological process is, accordingly, represented as a sequence of interdependent states. A state is defined as a condition in which the quality indicators, specifically the geometrical precision, retain their levels attained in preceding stages or transitions in the process. Each technological operation is described by a directional graph, with both sequential and parallel transformations of technological states from one to another included. Dimensional errors are calculated with the aid of a corresponding transformation matrix, whereupon an error compensation chart is drawn which biases the manufacturing variance of geometrical parameters so as to compensate errors caused by influencing factors in service and their deviation from normal delivery-acceptance level. These influencing factors are grouped into five categories: 1) ambient temperature; 2) force actions; 3) diffusion; 4) destructive actions; 5) radiation effects. The results of such an analysis indicate the feasibility of improving the precision of multicomponent mechanisms by 20-30% through application of novel technological principles. Figures 3, references 3: 2 Russian, 1 Western.
[108-2415]

UDC 621.822

## DYNAMIC STIFFNESS OF CLOSED GAS-STATIC BEARING WITH REGULATOR

Moscow MASHINOVEDENIYE in Russian No 6, Nov-Dec 83
(manuscript received 29 Jan 82) pp 105-109

SUKHOLUTSKIY, Yu. A., INGERT, G. Kh. and LUR'YE, B. G., Moscow and Odessa

[Abstract] The performance of a closed gas-static bearing with a regulator which includes a swinging baffle is analyzed for dynamic stiffness. The regulator consists of a pressure chamber between a base plate and a cover plate with hermetic sealing and a baffle plate mounted on torsion bars inside. The base plate has three holes, one orifice for lubricant inlet to the regulator and two throttling nozzles for lubricant feedback to the bearing. The baffle plate is slotted and acts as a valve which adjusts the bearing pressure during load fluctuations. The performance is analyzed on the basis of the corresponding equations of dynamics for the baffle plate in such a regulator, assuming symmetry of orifice and throttle nozzles through the regulator base plate as well as symmetry of clearances in the regulator and in the bearing respectively. The transfer function of this closed-loop system is determined from this system of equations after linearization and Laplace transformation. The results of analysis reveal that the dynamic stiffness depends not only on the frequency of regulator action, dropping to a minimum at some low frequency, but also on the volume of compressible fluid in that it decreases as the latter is made larger. Calculations for an LON 135 regulator indicate that here the dynamic stiffness drops below the static stiffness at some frequency below 30 Hz and drops very low when the volume of compressible fluid exceeds 1500 $cm^3$. Figures 2, references 8 (Russian).
[109-2415]

UDC 621.9:621.89

## IMPROVEMENT OF DYNAMIC CHARACTERISTICS OF GAS-STATIC BEARINGS

Moscow MASHINOVEDENIYE in Russian No 6, Nov-Dec 83
(manuscript received 9 Jun 82, after completion 22 Jun 83) pp 100-104

SHATOKHIN, S. N. and KODNYANKO, V. A., Krasnoyarsk

[Abstract] Gas-static bearings with compensation of gas discharge by means of plain or annular throttling diaphragms are considered, each type of diaphragm offering some advantages and drawbacks. Improvement of the static as well as dynamic characteristics by combining the advantages of both types is sought and found in theory on the basis of the mathematical model of an open axial bearing with double throttling. The equation of flow rate balance is formulated in the Prandtl approximation of a nonisentropic process and

disregarding the effect of gas compressibility in pockets. The static characteristics and the dynamic quality criteria are established in terms of the pressure distribution in the gaseous carrier layer, this pressure distribution function being determined from the solution to the corresponding boundary-value problem for the Reynolds equation of nonsteady flow with small deviations of the movable bearing element from its equilibrium position. Performance and design calculations reveal that the low static compliance of a plain diaphragm can be successfully combined with the absence of pockets behind an annular diaphragm by use of a rather large resonator tank in the pressure channel between a main throttle and a supplementary damper-throttle in series. Figures 3, references 7 (Russian).
[109-2415]

UDC 621.373.826.038.825

## CONTROLLER FOR THE ELECTRO-OPTICAL SHUTTER OF A DUAL PULSE LASER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 83 (manuscript received 1 Oct 82) p 221

MURAVITSKIY, M. A. and BORSHCHIYEVSKIY, V. M., Institute of Electronics of the Belorussian SSR Academy of Sciences

[Abstract] A unit for controlling the cavity Q of a dual pulse laser utilizes the independent discharging of two high voltage capacitors in an electro-optical shutter. The capacitors are charged to a voltage of 0.5 to 15 KV. The controller contains three regulated power supplies: two for the capacitors and a 0 to 12 KV DC bias supply for the shutter. The high voltage switchers in the controller can be controlled from any industrial dual channel square wave generator with an output amplitude of 10 V or more (for example, a G5-56). The output pulse amplitude is continuously variable from 0.5 to 15 KV; the bias voltage is continuously variable from 0 to 12 KV; the rise time of the pulses is no more than 0.5 KV/ns. The minimum delay between the pulses is 0.1 microsecond. The maximum switching frequency is 3 Hz. The controller is powered from the AC mains at 220 V, 50 Hz with a power consumption of 450 W. The dimensions are 510 x 500 x 310 mm and the weight is 30 kg. A photograph of the front panel is shown. Figure 1. [86-8225]

UDC 536.52

## PROCEDURE FOR WALL TEMPERATURE MEASUREMENT IN A METAL VAPOR LASER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 83 (manuscript received 18 Jun 82) pp 191-192

DIREKTOR, L. B., KARASEV, A. V., MALIKOV, M. M. and SKOVOROD'KO, S. N., High Temperature Institute of the USSR Academy of Sciences

[Abstract] The wall temperature of high temperature laser chambers using metal vapors can be measured without shutting down the pumping source by passing the beam through an interrupter to an optical pyrometer. This optical

chopper consists of a rotating and a stationary disc with holes in them. Synchronization is accomplished by shining another light source through the holes in the rotating disc onto a photodetector, in order to produce signals which trigger the pumping source. These signals are generated in a coincidence gate, which uses a master oscillator as a reference standard. The pulse frequency f in the pulse train triggering the pumping source and the pulse width $t_i$ are set by the master oscillator; the durations of the pulse train $t_p$ and the pauses $t_{pz}$ are determined by the disc rotational speed, the size of the holes as well as the number of holes. For the device used in this study: $t_p$ = 11 ms; $t_{pz}$ = 4 ms; f = 0.1 to 10 KHz, $t_i$ = 0.1 to 1 microsecond. Since the repetition rate of the discharge pauses was approximately 70 Hz, the observer sees the continuous luminescence of the chamber walls in the pyrometer ocular by virtue of the persistence of vision. The error was estimated as less than $\pm$20°C at a temperature of about 1,500°C. with a clean window. Results of wall temperature measurements of a Cu vapor laser are plotted graphically showing temperature as a function of the pumping supply voltage. A block diagram of the test configuration and a schematic of the four-transistor coincidence gate are provided. The authors would like to thank V. I. Pil'skiy for his useful advice in developing the procedure.
Figures 3, references 2: 1 Russian, 1 Western.
[86-8225]

UDC 621.378.3

## HOLLOW CATHODE CELL FOR PULSED LASERS USING METAL VAPORS AND THEIR CHEMICAL COMPOUNDS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 83
(manuscript received 19 Jul 82) pp 189-190

FUCHKO, V. Yu., KEL'MAN, V. A. and ZAPESOCHNYY, I. P., Uzhgorod University

[Abstract] A discharge in a hollow cathode is an efficient means of producing inversion and lasing with the ion transitions of metals. A hollow cathode, which is a stainless steel tube 3 mm in diameter and 35 cm long has 8 holes spaced 4 cm apart with diameters of 3 mm. The cathode is enclosed in a quartz envelope with holes corresponding to the cathode holes. The sectional anode was made in the form of individual stubs positioned at a distance of 12 mm from the corresponding holes in the cathode. The entire cell was placed in an asbestos jacket with a heating element. The pulsed supply provided a current pulse repetition rate of from 0.04 to 12.5 KHz, producing a stable discharge with the hollow cathode effect at a gas pressure of 1 to 150 mm Hg and a current of up to 100 A. The current pulse width at the base was 0.8 microseconds under typical conditions. This made it possible for the first time to study lasing via Cd ion transitions using mixtures of He+Cd and He+$CdBr_2$. Vapors could be produced at temperatures up to 900°C. The configuration of the hollow cathode cell and the pulse discharge generator is drawn; the lasing power at the 441.6 nm line in a He+Cd mixture is plotted as a function of the

current pulse amplitude, showing a peak around 8 A. Figures 2, references 3: 1 Russian, 2 Western.
[86-8225]

UDC 621.375.826

UTILIZING LIGHT FOCUSING BY GAS DISCHARGE MEDIUM FOR STABILIZATION OF EMISSION POWER OF He-Ne LASER AT WAVELENGTH OF 6401 ANGSTROMS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 83 (manuscript received 7 Mar 83) pp 187-188

GAVRILOV, D. N., RABINOVICH, E. M. and TUCHIN, V. V., Scientific Research Institute of Mechanics and Physics at Saratov State University

[Abstract] Emission from an He-Ne laser operating in the lowest transverse mode at a wavelength of 6,401 Å passes through a gas discharge cell and a stop which are positioned in series along the laser beam axis. A portion of the radiation is routed to a photodiode in a feedback loop by a semi-transparent mirror. The photodiode output is amplified and fed to a discharge current modulator inserted in series in the discharge circuit of the gas discharge cell. The focusing properties of the discharge and the size of the laser beam spot in the diaphragm stop plane change as a function of the discharge current in the cell. The phase of the signal in the feedback loop is chosen so that an increase in laser power is accompanied by an increase in the emission spot size and a power decrease reduces the diameter of the laser beam. A methane cell is placed in the laser to suppress the 3.39 micrometer lasing. This scheme effectively suppressed output power fluctuations up to frequencies of about 30 KHz. The efficiency of this regulation system fell off to zero at 60 KHz, which was due to the inertia in establishing the Ne atom concentration distribution in the $Ls_5$ state in the cross-section of the focusing cell. It is also possible to use semiconductor "lenses" with a variable focal length that are capable of changing the size of the output spot from an He-Ne laser at 6,328 Å by a factor of two or more. Figures 2, references 6: 5 Russian, 1 Western.
[86-8225]

UDC 621.384.64

EXPERIENCE WITH DEVELOPMENT OF SEALED LINEAR WAVEGUIDE ELECTRON ACCELERATORS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 83 (manuscript received 22 Feb 82) pp 11-13

SUVOROV, Ye. V. and KHAUSTOV, A. I., All-Union Scientific Research Institute for Nuclear Geophysics and Geochemistry

[Abstract] A sealed linear electron accelerator eliminates the need for vacuum pumps, valves, flanges and similar hardware, making it the only acceptable design for such geophysical applications as well as logging. This paper describes a sealed accelerator tube used as a transportable gamma radiation source. Ten such tubes have been built. The first models had vacuum gauges to monitor the internal pressure; it ranged between $10^{-5}$ and $10^{-6}$ N/m$^2$. The MTBF was more than 500 hours. The accelerator has an electron energy of 6 to 7 MeV with a pulsed current of 20 to 20 mA when driven by a 3 cm band transmitter with a pulse power of 500 KW; the accelerator weighs 9 kg, has an overall length of 2,300 mm and a maximum diameter of 88 mm. Because there are no external lines and pumps, the prestart time has been reduced to 3-5 minutes. The high vacuum allows the use of an oxide cathode having a large current density which reduces the electron beam diameter and facilitates its focusing. A drawing of the sealed accelerator tube is shown along with a graph plotting the temperature, pressure and gas flow as a function of time during the thermal vacuum sealing of the accelerator tube. Figures 2, references 4 (Russian).
[86-8225]

UDC 53.083.7-98:535.317.24/6

TELEVISION SYSTEM FOR MONITORING TARGET POSITION IN LASER THERMONUCLEAR FUSION EXPERIMENTS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 83 (manuscript received 5 Apr 82) pp 160-162

VASIN, B. L., VALUYEV, A. D., GORYACHUK, O. L., DANILOV, A. Ye., May, R. G., SKLIZKOV, G. V., FEDOTOV, S. I. and CHAUSHANSKIY, S. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A four-channel TV system has been developed for monitoring the positioning of working thermonuclear fusion targets in three dimensions with an error of $\pm 5$ micrometers. A target at a distance of from 250 to 350 mm can be located in a spatial volume of 10 x 10 x 10 mm with a magnification of 17; it can be set in three coordinates relative to a specified point in a volume of 1 x 1 x 1 mm with a magnification of 250. The configuration of the system using an He-Ne laser is diagrammed and discussed. The spherical

targets have diameters of 50 to 800 micrometers. The spatial resolution in the target setting mode is 62 lines/mm. The ultimate magnification of the system is 500; photographs of TV images of polystyrene and glass targets are shown. This paper is an abridged version of Preprint No. 110 of the USSR Academy of Sciences Physics Institute imeni P. N. Lebedev, Moscow, 1983, 26 pp with illustrations. The authors are grateful to N. G. Basov for supporting the work and Yu. V. Senatskiy for his useful comments and assistance with the work. Figures 3, references 4 (Russian).
[86-8225]

UDC 621.373.8.038.823

## MINIATURIZED PULSED $CO_2$ LASER WITH SEALED ELECTRON SOURCE

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 83 (manuscript received 14 Dec 82) pp 185-186

BYCHKOV, Yu. I., ORLOVSKIY, V. M., OSIPOV, V. V. and POTERYAYEV, A. G., Institute of High Current Electronics, Siberian Department, USSR Academy of Sciences, Tomsk

[Abstract] A new miniature electron beam-controlled $CO_2$ laser (the MIG-3) contains an electron accelerator, gas cell and DC supply in one large unit (0.22 x 0.16 x 0.7 m) and the accelerator power supply and laser control panel in a second smaller unit. The overall weight of the instrument in 30 kg. The electron beam is controlled by four vacuum diodes in parallel; a 180 KV pulse is fed to the vacuum diode inputs from a "NORA" series-produced X-ray source (the "MIRA-3D" may also be used). The total electron beam current from all diodes was 600 A following the foil with a half-height width of 10 ns. The lasing medium is $CO_2$:$N_2$ = 1:1 at 4.5 atm. The maximum stimulated emission pulse energy was 1 J with an efficiency of 8% when the pressure was 4 atm. With a pulse repetition rate of 4 Hz, the average power consumption of the unit was 100 W. The authors are grateful to P. G. Alimov for assisting in the design of the miniature DC supply. Figures 2, references 5 (Russian).
[86-8225]

FLUID MECHANICS

UDC 531.51+532.592

# CENTRAL BURST OF SIMULTANEOUSLY ROTATING AND GRAVITATING BODY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 273, No 4, Dec 83
(manuscript received 28 Apr 83) pp 825-829

GOLUBYATNIKOV, A. N. and CHILACHAVA, T. I., Moscow State University imeni M. V. Lomonosov

[Abstract] The astrophysical problem of bursts in simultaneously rotating and gravitating celestial bodies is treated as an axisymmetric one for a homogeneous ellipsoid bursting at the center. It is formulated in a system of spherical coordinates with the sought distributions of pressure and gravitational potential appropriately stipulated. The corresponding equations of steady axisymmetric adiabatic motion of a gas during the initial stage, before the shock wave reaches the surface, are formulated in Lagrange variables and by the asymptotic method of a thin shock layer with $\varepsilon = \gamma - 1$ as the small parameter ($\gamma$- adiabatic exponent) and with appropriate boundary conditions at the shock wave front. Consideration is taken of the law of momentum conservation and the condition of continuity for the tangential velocity komponent as well as for Euler and Lagrange variables. Emergence of the shock wave at the body surface, at the poles first, results in formation of jets associated with expansion of a gas into vacuum. The authors thank Academician L. I. Sedov for helpful discussion. Article was presented by Academician L. I. Sedov on 19 April 1983. References 3 (Russian). [103-2415]

UDC 532.517.4

## SEPARATION FLOW PAST BODIES WITH FIXED SEPARATION SITES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 273, No 4, Dec 83
(manuscript received 9 Nov 82) pp 821-825

BELOTSERKOVSKIY, O. M., academician, BELOTSERKOVSKIY, S. M., DAVYDOV, Yu. M. and NISHT, M. I., Computer Center, USSR Academy of Sciences, Moscow; Air Force Engineering Academy imeni N. Ye. Zhukovskiy

[Abstract] Separation flow past bodies was studied by way of computer experiments. Flow in a continuous medium at a high Reynolds number (Re = $10^5$ - $10^7$) was simulated on the basis of Euler equations for nonsteady flow of an ideal medium and by two fundamentally different methods. The method of discrete vortices was used for solving nonlinear steady-state and transient-state equations applicable to bodies in incompressible media. This method yielded reliable results in analysis of flow past carrier surfaces with vortex trails, plane flow with initial Prandtl or Karman vortex trail behind plates, plane flow with mixing and rotation in vane cascades, three-dimensional flow with acceleration past bodies made of permeable materials, and three-dimensional flow with transformation of vortex sheet into vortex filaments at wings. The method of large particles was used for flow of a gas at subsonic and supersonic velocities, plane axisymmetric flow, and three-dimensional flow with vortex spirals. The results obtained by both methods were verified by other mathematical methods. The next task is verify the results by physical experiment and numerical-physical analysis. Figures 3, references 10: 9 Russian, 1 Western.
[103-2415]

UDC 533.17

## DISCHARGE OF IDEAL GAS INTO VACUUM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 273, No 4, Dec 83
(manuscript received 25 Oct 82) pp 817-820

BAUTIN, S. P. and DERYABIN, S. L., Ural Electromechanical Institute of Railroad Transportation Engineers, Sverdlovsk

[Abstract] Three-dimensional nonisentropic flow of an ideal gas adjoining a vacuum or occurring upon instantaneous removal of a solid barrier which separates it from a vacuum is analyzed as a problem of decaying discontinuity. The solution to the corresponding system of three vector equations of motion and the equation of state, using the function $\sigma = \sigma_0(x) = \rho^{1/2(\gamma - 1)}$ ($\rho$ - density of gas, $\gamma > 1$), is sought in the form of special converging series. A convergence test reveals that the gas particles move along straight lines at constant velocity until infinite gradients of gas-dynamic parameters build up at the vacuum boundary. Four theorems are proved pertaining respectively

to the existence of a unique analytical solution in the vicinity of the discontinuity surface, to its convergence region, to the constant velocity transient following the decay of the discontinuity, and to the corresponding Cauchy problem. The proof of the first theorem reduces to an analog of the proof of the Cauchy-Kowalewska theorem and it yields a lemma pertaining to the coefficients and exponents in the series. The behavior of the first derivatives of gas-dynamic parameters at the free gas-vacuum boundary is described by a system of transport equations reducible to a system of ordinary differential ones. After a long transient period the theorems remain valid only within some regions of both the free boundary and the discontinuity surface. Article was presented by Academician N. N. Yanenko on 14 October 1982. References 6 (Russian).
[103-2415]

UDC 621.165.533.6

MORE PRECISE NUMERICAL SIMULATION OF TRANSSONIC FLOW THROUGH PASSAGES IN TURBOMACHINES

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 12, Dec 83 (manuscript received 9 Feb 83) pp 63-67

KREMENETSKIY, M. D., candidate of physico-mathematical sciences, and YABLONIK, R. M., doctor of technical sciences, professor, Scientific Production Association imeni I. I. Polzunov

[Abstract] A method of solving boundary-value problems in gas dynamics by numerical simulation is proposed which retains the equations of motion in a rigorously conservative form even in any nonstationary system of curvilinear coordinates. It is based on transforming the fundamental system of equations for an ideal gas in divergence form from a stationary Cartesian system of coordinates to a moving system of curvilinear coordinates by tensor formalism. The main feature of this system of equations in the new form is that the momentum equation has been projected onto the axes of the original Cartesian system and thus absolute Cartesian components of the velocity vector have been selected as unknown functions. Any other choice of projections would detract from the rigorous conservatism and consequently degrade the numerical simulation. For illustration, the flow through passages between blades in a ring array of an axial turbine is described in this way in a system of curvilinear coordinates (meridional $x^1$,$x^3$ and axial $x^2$) moving with the blades. Description of a three-dimensional flow is derived as a special case, and using the hypothesis of a linearly averaged axisymmetric flow further simplifies the system of equations to a two-dimensional one. References 6 (Russian).
[91-2415]

UDC 621.438

EFFECT OF ROTATION ON THERMAL STATE OF RUNNER BLADE THROUGH EFFECT ON HEAT TRANSFER ON COOLANT SIDE

Moscow TEPLOENERGETIKA in Russian No 1, Jan 83 pp 51-52

MITYAKOV, V. Yu., candidate of technical sciences, and RIS, V. V., candidate of technical sciences, Leningrad Polytechnic Institute

[Abstract] An experimental study and subsequent analysis have established that rotation of the runner blades in high-temperature gas turbines, through action of the Coriolis force, produces secondary flow in the passages and thus affects the heat transfer from blades to coolant. This is indicated by the profile of local heat transfer coefficients, which changes with a tendency to flatten along and around the blade as the Rossby number increases. This conclusion was verified on a GTZ-150 gas turbine running at 3000 rpm and operating at an inlet temperature of 1000 K, with 0.16 kg/s of cooling air at 473 K and 1.02 MPa for each blade. The heat transfer on the coolant side can be described either by the relation $Nu = 0.021Re^{0.8}Pr^{0.43}$ disregarding the effect of rotation or by the relation $Nu_\omega/Nu_0 = 1 - 1.55\cos\varphi Ro^{-0.56}$ (Re = idem $\geq 10^4$, Ro $\geq$ 20) including the effect of rotation. Figures 3, references 8: 5 Russian, 3 Western.
[88-2 15]

UDC 533.9:536.244

THERMAL CHARACTERISTICS OF PLASMA REACTORS WITH CYLINDRICAL AND CONICAL MULTIJET MIXING CHAMBERS

Minsk VESTSI AKADEMII NAVUK BSSR: SERYYA FIZIKA-ENERHETYCHNYKH NAVUK in Russian No 4, Oct-Dec 83 (manuscript received 22 Oct 82) pp 85-88

BUROV, I. S., YEMOLAYEVA, Ye. M., ZABRODIN, V. K. and MOSSE, A. L., Institute of Heat and Mass Transfer imeni A. V. Lykov, BSSR Academy of Sciences

[Abstract] An experimental study of plasma reactors was made for a comparative efficiency analysis of cylindrical and conical mixing chambers. Also determined were the heat losses to electrodes in the electric-arc heater and to walls of the multijet mixing chamber, both depending on the input power and the mode (tangential or radial) of plasma jet injection. The results reveal that the efficiency of any mixing chamber increases with increasing enthalpy of the gas and, at constant enthalpy, with increasing gas flow rate. The higher efficiency of a conical mixing chamber, despite the larger radial temperature gradient, is attributed to a thicker thermal boundary layer. The study has also yielded data on the motion of disperse silica in gaseous suspension axially injected into the mixing

chamber. Experimental data on heat transfer from hot plasma to reactor chamber can be generalized by the relation $St = ARe^{m}Pr^{-0.67}$, with m = -0.66 and A = 1.012 for conical chambers or A = 1.7 for cylindrical ones. Figures 4, references 7 (Russian).
[87-2415]

UDC 621.8.031

EFFECT OF HYDROMECHANICAL INERTIA FORCES ON STABILITY OF CYLINDRICAL HYDRODYNAMIC BEARING

Moscow MASHINOSTROYENIYE in Russian No 5, Sep-Oct 83
(manuscript received 5 Feb 82, after completion 14 Jan 83) pp 96-102

ANDREYCHENKO, K. P., Saratov

[Abstract] The stability of a hydrodynamic bearing under inertia forces as well as viscous and body forces is analyzed on the basis of the complete corresponding equations of hydrodynamics. This system of three partial differential equations is formulated on dimensionless variables for a cylindrical inner race supported by a layer of incompressible fluid. They are solved, upon introduction of the new radial coordinate $r - R_2$ ($R_2$- outside radius of inner race) and the average velocity <V>. Double integration yields the reaction of the supporting fluid layer and the condition for stability in terms of race geometry and density, also the stability limit under vertical acceleration. The theoretical results have been verified experimentally on an inner race rotating at a constant speed about a fixed axis. Heavy races were found to become self-excited into oscillations together with the fluid, in the form of a half-speed vortex. Figures 2, references 8 (Russian).
[108-2415]

UDC 533.6.013.2

EXACT SOLUTION TO PROBLEM OF INTERACTION BETWEEN WEDGE MOVING AT SUPERSONIC VELOCITY AND INTERFACE OF TWO GASEOUS MEDIA

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian No 5, Sep-Oct 83 (manuscript received 19 May 82) pp 94-98

TUGAZAKOV, R. Ya., Zhukovskiy

[Abstract] Motion of a wedge at supersonic velocity toward a boundary separating two gaseous media is analyzed, considering a compression shock wave but not a rarefaction wave reflected by that boundary as the wedge approaches. The shock wave is assumed to return to the wedge normally to its face. The state of the gas in both regions is described with boundary

conditions at their interface including the velocity discontinuity, in a system of coordinates fixed at the triple point and moving at constant velocity with the wedge. The velocities in the two gaseous regions cannot be equal, the pressures and the velocities on both sides of the contact discontinuity surface at the wedge must be respectively equal, and the streams at that surface must be parallel upon their deflections behind the forward wave and the reflected wave respectively. The problem is formulated mathematically with the aid of 12 available relations at the three pressure jumps in the system. On this basis is then calculated the compression ratio as function of the Mach number of the oncoming stream, for a fixed adiabatic exponent and various wedge angles, and as function of the adiabatic exponent over the k = 0-2.0 range at a fixed Mach number (M = 2.4). Figures 4, tables 2, references 9: 8 Russian, 1 Western.
[93-2415]

UDC 533.6.011.55.011.6

THEORY OF HYPERSONIC THREE-DIMENSIONAL FLOW OF NONSTEADY GAS STREAM WITH RELAXATION PAST THIN WING WITH ARBITRARY ASPECT RATIO

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian
No 5, Sep-Oct 83 (manuscript received 28 Jun 82) pp 88-93

KUZNETSOV, M. M., Moscow

[Abstract] Hypersonic three-dimensional flow of an unsteady gas stream with relaxation past a thin wing is analyzed theoretically, first for a wing with a small aspect ratio and dimensions $b = O(\sqrt{\varepsilon})$, $c = O(\varepsilon)$, $L = 1$ and corresponding boundary conditions at the front of the shock wave with physicochemical transformations in the shock layer. A wing with finite span is considered next, in accordance with the theory of a thin shock layer, and the problem is solved for the three characteristic cases of the angle of the Mach cone comparable with, much smaller than or much larger than the vertex angle of the wing. A system of integral equations for the pressure distribution in the special case of a steady-state equilibrium-state turbulent sublayer at a plane wing surface is obtained which becomes reducible to a single nonlinear ordinary differential equation with a singular point of the "saddle" kind. The author thanks V. Ya. Neyland for interest in this study. References 9: 8 Russian, 1 Western.
[93-2415]

UDC 532.526.013

EXCITATION OF TOLLMIN-SCHLICHTING WAVES IN BOUNDARY LAYER AT VIBRATING SURFACE OF INFINITE-SPAN SWEPTBACK WING

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian
No 5, Sep-Oct 83 (manuscript received 30 Jul 82) pp 70-74

TUMIN, A. M., Moscow

[Abstract] Flow in the boundary layer at a vibrating surface of an infinite-span sweptback wing is analyzed on the basis of the corresponding Navier-Stokes equations and equation of state in dimensionless variables. Displacement and velocity components as well as temperature are referred to those in the oncoming stream, with some characteristic dimension selected as scale of length , pressure is referred to the velocity head in the oncoming stream. The problem is an ill-conditioned one, which requires the constraint that it have a solution with a finite buildup exponent. The problem is solved for a flow weakly nonuniform in the absence of perturbations, the solution being sought by expansion into a biorthogonal array of vectors characterizing local uniformity. Summation over the discrete spectrum and integration over the continuous spectrum, then the method of steepest descent, yield the Tollmin-Schlichting wave excited near the resonance point and with it the amplitude of whatever fluctuation velocity, temperature, or mass rate is of interest. Numerical results are shown for a typical symmetric NACA 0012 wing profile with a 30° sweepback angle and a 1.5 m chord at a zero angle of attack, in a stream with a Mach number $M = 0.28$ at a temperature of 300 K and under a pressure of $10^4$ N/m$^2$. Figure 1, references 9: 8 Russian, 1 Western.
[93-2415]

UDC 535.5:621.22

CALCULATION OF APPARENT MASSES IN BLADE RING

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian
No 5, Sep-Oct 83 (manuscript received 6 Aug 82) pp 56-62

TKACHEVA, L. A., Novosibirsk

[Abstract] Apparent masses in a three-dimensional turbine blade ring vibrating harmonically in an ideal incompressible fluid are calculated, assuming the N blades of the ring array to be infinitesimally thin and to be contained between two infinitely long coaxial cylindrical surfaces. The form of the blades is described by equations of a helical surface and the behavior of the fluid is described by equations of potential flow with zero circulation and with stand-still at infinity. The problem is formulated in terms of the Laplace equation in dimensionless cylindrical coordinates with appropriate boundary conditions, for identidal small harmonic vibrations of all blades with a uniform phase shift between them. The problem is solved analytically

with the aid of the Cauchy-Lagrange integral and Chebyshev polynomials. Numerical evaluation of double singular integrals is done by reduction to recurrent integrals and has been programmed on a BESM-6 high-speed computer. The apparent masses are then calculated according to the theory of plane grids. Convergence of this method has been established on the basis of numerical experiments. Figures 3, table 1, references 6 (Russian).
[93-2415]

UDC 532.526.5

INTERACTION OF UNSTEADY SPATIAL BOUNDARY LAYER WITH HYPERSONIC FLOW NEAR RAPIDLY HEATED PORTION OF SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 5, May 83 (manuscript received 6 Apr 82) pp 65-72

KAZAKOV, A. V., Moscow

[Abstract] Unsteady three-dimensional flow is produced by heating a small portion of the surface of a flat plate in a hypersonic flow. The distance from the leading edge of the plate to the portion of the surface whose temperature is increased by an amount on the order of the initial surface temperature by means of any inertnal or external energy source is approximately the same as the distance from the side edges of the plate. The interaction of the laminar boundary layer with the external hypersonic flow is slight. The gas is ideal with a constant specific heat. An analysis of the resulting Navier-Stokes equations shows that with steady planar and three-dimensional flows, three characteristic regions can be distinguished near the heated section. Region 1 is the perturbed portion of the nonviscous hypersonic flow; in region 2, whose thickness is on the order of the unperturbed boundary layer in front of the interaction region, the flow is nonviscous with vortical turbulence. Region 3 is a viscous layer near the wall in which the perturbations of the velocity and enthalpy are on the order of these quantities at the surface of the obstacle itself in the unperturbed boundary layer. The analytical equations derived for such unsteady flows in this paper are general forms independent of the Mach number of the incident flow, the Reynolds number and other flow parameters. The theoretical treatment adduces no applications or sample calculations. Figures 4, references 11: 9 Russian, 2 Western.
[97-8225]

UDC 533.6.011

## HYPERSONIC FLOW AROUND FLAT BODY IN CASE OF INTENSE RADIATIVE HEAT EXCHANGE

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian
No 5, May 83 (manuscript received 22 Apr 82) pp 126-129

NEMCHINOV, I. V. and POPOV, S. P., Moscow

[Abstract] Velocities of 50 to 70 km/sec are attained by meteorites entering a planetary atmosphere. At such velocities radiation has a substantial impact on the flow pattern around the body. For solids 1 to 10 m and more in diameter, at moderate altitudes energy transport by radiation is described by a radiant heat conductivity approximation. This paper studies such "radiation" flow modes using numerical estimates. The steady-state two-dimensional problem of a hypersonic flow of a nonviscous radiating gas around a flat thermally insulated body is solved numerically taking into account the radiative energy transport. The occurrence of a heated region around the body with dimensions that are an order of magnitude greater than the size of the solid itself is noted; the temperature here proves to be practically equalized while the gas velocity is close to that of the incident flow (the heated gas flow has a Mach number of 3 to 6). A narrow region of strongly compressed gas is produced immediately ahead of the solid. At the higher incident gas velocities, the flow far from the body can be approximated by replacing it with a heat source having a specific power described by a simple analytical expression. The proposed procedure makes it possible to determine the detailed flow pattern around such bodies in these "radiation" modes, where radiative heat conductivity is dominant; the pattern proves to be quite different from the usual "gas dynamic" modes. The authors are grateful to O. S. Ryzhov for assisting in this work. Figures 4, references 5: 4 Russian, 1 Western.
[97-8225]

UDC 533.6.011:51

## TRANSONIC FLOW AROUND PROTRUDING CORNER WITH FREE STREAMLINE

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian
No 5, May 83 (manuscript received 7 May 82) pp 130-137

DIYESPEROV, V. N., Moscow

[Abstract] An ideal gas flow parallel to a plane encounters a turning point where the plane breaks back acutely away from the flow. The transonic gas flow around this corner is described by an asymptotic analysis of a system of Navier-Stokes equations when the Reynolds number approaches infinity in the vicinity of the corner point. The ultimate flow is the free streamline from the vertex of this corner angle, at which the speed of sound is achieved. The equations describing the boundary layer flow

near this trailing edge are written and solved assuming that the coefficient of viscosity is a linear function of temperature and that the surface of the angle is thermally insulated. The detailed theoretical treatment provides no specific applications or sample calculations. Figure 1, references 15: 9 Russian, 6 Western.
[97-8225]

WAVE DRAG OF ELONGATED ASTROID BODIES AT MODERATE SUPERSONIC FLIGHT VELOCITIES

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian
No 5, May 83 (manuscript received 10 Feb 82) pp 146-151

FOLLE, M. I., Moscow

[Abstract] Since the optimal star-shaped body with pointed extremities found in the case of large Mach numbers satisfies the major constraints of linear theory, the wave drag can beedescribed by a formula which reduces the three-dimensional problem to a plane boundary value problem. The given formula is written as a function of parameters which include the number of sides of the star, 2n; the Mach number, M, and $B^2 = (M^2 - 1)^{1/2}$; the half-angle at the vertex of one of the extremities formed by a line running from the center of the body to this vertex. The main conclusion is that for any combinations of the parameters RB (R is the maximum thickness of the body), n, the vertex half-angle and yet a fourth parameter which describes the longitudinal contour of the body, the astroid configuration is superior in terms of drag to the equivalent axially symmetric form (equivalent with respect to the midsection area and aspect ratio). This is illustrated graphically for six slender shapes: a circle, pentagon, square, triangle and two five-pointed stars. The author is grateful to V. A. Levin and A. L. Gonor for their attnetion to the work. Figures 4, references 12: 9 Russian, 3 Western.
[97-8225]

UDC 539.3

# STUDY OF LARGE VISCOPLASTIC STRAINS IN CYLINDRICAL SHELLS BY METHOD OF MAGNETIC-PULSE LOADING

Moscow MASHINOVEDENIYA in Russian No 5, Sep-Oct 83
(manuscript received 3 May 82) pp 73-80

BAZHENOV, V. G., LOMUNOV, V. K., PETROV, M. V. and UGODCHIKOV, A. G.,
Gorkiy and Cheboksary

[Abstract] Dynamic stress-strain curves for viscoplastic materials have been constructed on the basis of experimental data obtained by magnetic-pulse loading of rings and cylindrical shells. Tests were performed with an MIU-20/5 magnetic loading machine, its capacitor bank of 1600 μF with a natural frequency of 12.6 kHz capable of delivering 20 kJ of energy per pulse. Measurements were made with an inductive pressure transducer and an optoelectronic displacement transducer. The latter device included provisions for splitting a laser beam into two identical beams along diametrally spaced generatrices of a cylinder, particularly useful for measuring radial deflections with a resolution of $10^{-2}$ mm (at a total deflection of 3.5 mm). Deformation of a generatrix was recorded by an SFR-2M photoreceiver in 2 μs intervals, radial displacements and the derivative of magnetic induction were plotted on oscillograms. The procedure for processing the experimental data, automated with the aid of a YeS-1020 Unified System computer, involves plotting the deflection $w(t)$ and the pressure $p(t)$ as functions of time, then calculating the velocity $\dot{w}$ and the acceleration $\ddot{w}$ as well as the second invariants $I_{2\sigma}, I_{2\varepsilon}$ of the stress tensor and the strain tensor with constant second invariant $I_{2\dot{\varepsilon}}$ of the strain rate tensor for plotting $I_{2\sigma} = f(I_{2\varepsilon}, I_{2\dot{\varepsilon}})$ curves. The mean stress-strain curves are then obtained by the method of least squares. This procedure was applied to specimens of aluminum alloys D16T and AMg6M, the former annealed at 390° for 45 min and then air cooled. Because of the low electrical conductivity of these materials, rings and cylindrical shells were clad with a layer of high-conductivity of these material with known stress-strain characteristic on the inside. The experimental results were evaluated on the basis of the geometrically nonlinear Timoshenko theory for double-layer structures, assuming a small shear strain and an ideal initial shape. The experimental data were also checked for continuity of contact between layers. They were also checked against theory, namely solution of the corresponding equations of motion based on the principle of virtual work by the numerical method of finite differences. Three modes

of deformation were analyzed in this way. In the mode of free expansion the difference between radial displacements according to theory and experiment did not exceed 6% for the D16T alloy with up to 13% residual strain and 7% for the AMg6M alloy with up to 21% residual strain. In the necking mode both theory and experiment revealed two zones, a cylindical one and a transitional one, under an electromagnetic load. In the grooving mode long shells were found to deform along a cylindrical zone, with experimental and theoretical data agreeing within 5% at circumferential strains of up to 16%. Figures 6, references 8 (Russian).
[108-2415]

UDC 624.0.74:539.319

ESTIMATION OF LOCAL STRESS INTENSITY IN FLANGED THIN-WALL SHELL STRUCTURES UNDER HEAVY THERMAL LOAD

Moscow MASHINOVEDENIYE in Russian No 5, Sep-Oct 83
(manuscript received 24 Dec 82) pp 64-72

KHOROSHILOV, V. N., KOTOV, P. I. and GUSENKOV, A. P., Moscow

[Abstract] Components of a gas turbine are examined for stress intensity as typical flanged shell structures under heavy thermal load. The stress intensity in such elements, especially at the shell-flange transition, is estimated on the basis of temperature distributions in four stages of a load cycle: 1) initial cold state (170°C) with small longitudinal temperature gradient; 2) fast heating (to 470°C) during load application (5-10°C/s); 3) maximum temperature (600-700°C) in steady state (24 min) following temperature equalization with attendant decrease of the longitudinal temperature gradient; 4) temperature drop below initial level during fast load dumping with attendant buildup of longitudinal temperature gradient in opposite direction. Calculations are made and stress diagrams are plotted for two types of cylindrical shells and a spherical shell with ratio of wall thickness to inside radius h/R = 0.005-0.01 and corner radii at the flanges of 0.6-2.5 mm. Stress analysis is based on solution of the thermoelasticity problem for axial and meridional forces and for bending moments in an axisymmetric temperature field. The corresponding system of eighth-order partial differential equations has been solved by numerical methods according to an algorithm programmed on an M-220 computer. Evaluation of load capacity and strength requires, in addition, analysis of thermoplastic behavior. Figures 7, tables 2, references 7 (Russian).
[108-2415]

UDC 624.074-539.319

## STRESSED-STRAINED STATE OF FLANGED SHELLS UNDER HEAVY THERMAL LOAD BEYOND ELASTIC LIMIT

Moscow MASHINOVEDENIYE in Russian No 6, Nov-Dec 83
(manuscript received 2 Feb 83) pp 56-66

GUSENKOV, A. P., KOTOV, P. I., KHOROTILOV, V. N. and KUZNETSOV, S. F., Moscow

[Abstract] Stresses and strains in thin-walled shells with flanges in a gas turbine are analyzed beyond the elastic limit of the material. Two kinds of such shells are considered representing a contrast in elastoplastic deformation characteristics, a "cold" one and a "hot" one subject to temperature cycling in the danger zone over the ranges 170 $\rightleftarrows$ 610°C and 220 $\rightleftarrows$ 670°C respectively. The analysis is based on solution of the problem of thermal stresses for thin-walled shells according to the theory of variable-stiffness shells and of the problem of nonisothermal deformation. The deformation process is assumed to consist of an isothermal electroplastic deformation at the initial no-load temperature till the maximum temperature drop is reached and subsequent elastoplastic deformation during alternating tension and compression half-cycles. Isochronous stress-strain curves are calculated and plotted accordingly, with residual stresses taken into account. The analysis is further refined by appropriately applying the theory of plasticity and considering rheological effects, specifically creep. Calculations programmed on a computer by the finite element method were made for KhN60VT heat-resistant alloy steel - a typical thermocyclically stabilizable material. Figures 7, table 1, references 12 (Russian).
[109-2415]

UDC 624.07:534.1

## PLANE MOTION OF SOLID BODY ON ROUGH SURFACE OF ANNULAR BEARING ROTATING ABOUT ITS AXIS PERPENDICULAR TO PLANE OF MOTION

Moscow MASHINOVEDENIYE in Russian No 1, Jan-Feb 84
(manuscript received 12 Apr 82, after completion 20 Aug 82) pp 13-15

PANOSKO, G. Ya., Moscow

[Abstract] Rectilinear horizontal motion of a solid body in an annular bearing with rough surface rotating about its vertical axis is analyzed, such a motion being characterized by an apparent conversion of dry friction to viscous friction. The dry friction force is assumed to depend nonlinearly on the sliding velocity:

$$F = f_1 \frac{mg}{\pi (R_2^2 - R_1^2)} \left(1 - 3b \frac{v_r^3}{v_0}\right)$$ ($f_0$ - minimum value

of friction coefficient, $f_1$ - static friction coefficient, $v_0$ - sliding velocity at which $f = f_0$, $b = (f_1 - f_0)/2f_1$, $b = 0$ for Coulomb friction). Calculation of the total friction force, which involves evaluation of a double (surface) integral, reveals that at some optimum angular velocity the friction is minimum, namely at $\omega_{opt} = v_0[b(R_1 + R_2)(R_1^2 + R_2^2]^{-1/3}$ ($R_1$,$R_2$- respectively inside and outside radii of bearing). As the angular velocity increases, the efficiency of friction conversion decreases. The results can be useful in practical attempts to reduce dry friction and thus prevent self-excited vibrations. Figures 2, references 6 (Russian).
[110-2415]

UDC 621.86:534.1

## SYSTEM FOR TORQUE CONTROL OF UNBALANCED ROTOR DURING PASSAGE THROUGH RESONANCE

Moscow MASHINOVEDENIYE in Russian No 1, Jan-Feb 84
(manuscript received 18 Oct 82) pp 16-23

KEL'ZON, A. S. and MALININ, L. M., Leningrad

[Abstract] Starting and acceleration of an unbalanced rotor in a machine with one rotational and several vibrational degre s of freedom is described by a system of nonlinear differential equations, which serve as basis for devising a torque control for such a rotor during its passage through resonance. The general method of analysis is applied to a rotating machine with insufficient drive power to cope with the resonance condition, a typical case being a combination machine tool and test stand for grinding wheels. For the purpose of analysis, the equations of motion are converted from matrix and vector form to normal coordinates, or binormal ones in the case of a nonself-adjoint system with at least one asymmetric matrix of coefficients, through diagonalization with critical speed as the argument. The various critical speeds of a rotor are assumed to be widely spaced, by at least 30%, so as to avoid overlap. An approximately optimum law of torque control has been proposed on the basis of "slow" asymptotic variables in the mass-speed plane. This law has been synthesized so as to include the influence of six parameters (damping coefficient, unbalance factor squared, torque before and after control action, nominal speed, instantaneous speed during transition) and the indeterminacy of some parameters (damping coefficient, unbalance factor) in thessense that they are either unknown or stipulated with an error. Figures 6, references 11: 9 Russian, 2 Western.
[110-2415].

UDC 621-752

## AUTOMATIC ELIMINATION OF STATIC UNBALANCE OF ROTOR IN ANISOTROPIC BEARINGS

Moscow MASHINOVEDENIYE in Russian No 1, Jan-Feb 84
(mansucript received 31 Mar 82, after completion 2 Dec 82) pp 24-25

NESTERENKO, V. P., Tomsk

[Abstract] The method of proving that balls retained in an annular groove of a rotor so as to form an anisotropic bearing will automatically eliminate the static unbalance at rotor speeds higher than the natural frequency is extended to a vertical rotor in an anisotropic bearing of this kind. The conditions for stability and asymptotic stability of steady rotation are established on the basis of analysis and calculations for an ideally stiff rotor in a bearing with only two balls. The results reveal that transition from stable to unstable rotation occurs not only at a critical speed but also at the speed which corresponds to equal amplitudes of rotor vibrations along two orthogonal horizontal coordinates, they also confirm Laval's principle of self-balancing above critical speed. Figure 1, references 4 (Russian).
[110-2415]

UDC 539.3

## APPROACH TO SOLVING PROBLEM OF ACOUSTIC WAVE DIFFRACTION BY ELASTIC SHELL

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 11, Nov 83
(manuscript received 20 Aug 82) pp 31-35

VLAZHIYEVSKAYA, O. V., L'vov State University

[Abstract] Traditional approaches to the determination of pressure perturbations in a fluid when a nonsteady-state acoustic wave is scattered by an elastic shell are based on the separation of variables in the wave equation, and thus have limited applications. This paper analyzes a transversally isotropic spherical shell immersed in an ideal fluid; an acoustic wave of finite length impinges on the shell. The scattered pressure field is determined using a generally adopted linear formulation where the motion of the shell is described by Timoshenko type equations, assuming that the Young's modulus in the middle surface is independent of the transverse shear modulus. The proposed construction of the near-front asymptotic behavior of the echo from the shell can be used in the case of shells with a noncanonical configuration. The resulting analytical equations are used to plot the pressure scattered by a steel shell in water exposed to a short-lived incident wave as a function of time. No specific applications are noted for the new algorithm. Figure 1, references 6 (Russian).
[99-8225]

UDC 539.3

# SOLVING STATICS PROBLEMS OF THICK-WALLED CYLINDRICAL SHELLS WITH LOOSE CONTACT BETWEEN LAYERS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 11, Nov 83 (manuscript received 22 Apr 83) pp 40-43

VASILENKO, A. T., GRIGORENKO, Ya. M., Corresponding Member of the UkSSR Academy of Sciences and PANKRATOVA, N. D., UkSSR Academy of Sciences Institute of Mechanics, Kiev

[Abstract] Thick-walled layered shell structures are subjected to axial stresses at the end faces, which are distributed so that the ends remain flat. The shells are made of orthotropic materials and the friction at the contact surface between the layers is disregarded, with the assumption of ideal slippage over the contact area. This paper derives analytical expressions describing the deformed stressed state of such shells in a spatial formulation. The solution is illustrated with the example of axially symmetric deformation of a two layer shell of isotropic materials. Graphs are plotted for this case showing both the tangential and axial stress distributions in the shell. With slippage between the layers in a homogeneous shell, in the case where the shell diameter is equal to its length, the tangential stresses are 25% of their value when the layers are tightly joined together; there is also a reduction in the axial stresses.
Figures 2, references 4 (Russian).
[99-8225]

UDC 006,063:531.7.087.92

# APPARATUS FOR CERTIFICATION OF ANGULAR-DISPLACEMENT TRANSDUCERS

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 10, Oct 83 pp 20-22

B. N. IVANOV

[Abstract] Apparatus for determining the accuracy of inductive, photoelectric, and other angle-to-code converters with angular-displacement transducers is being developed at the Ukrainian Measurements and Standardization Center. The operation of the various test stands for this purpose is based on measuring the electric output pulse signals from the sample transducer and a reference transducer and recording them in the form of phase-difference diagrams, while the shafts of both transducers rotate synchronously, then determining the error of the sample transducer from those diagrams superposed on one another so as to correspond to the same angular positkon of both shafts. The method has already been used for transducers measuring the kinematic error of gear cutting tools and for photoelectric transducers with the kinematic linkage replaced by direct coupling of sample transducer and reference transducer through their shafts. The mechanical components of such a test stand include an electric drive motor with speed regulation, a belt transmission, a worm gear for speed reduction, a flexible coupling, a bellows, a stator fixture, a centering mechanism, an index dial, a digital counter, and a tape winder. Prototypes of such a test stand were checked against a special phase meter with the KN-6M kinematometer produced at the Chelyabinsk Instrument Manufacturing Plant and with an N327-1 recording instrument produced at the Krasnodarsk Instrument Manufacturing Plant. These tests stands have been found to be adequate for certification of transducers in the 1-2" precision class. Figure 1, references 9 (Russian).
[102-2415]

UDC 62-408:620.179.1:006.354.03

# MEASURING ROUGHNESS OF ULTRASMOOTH SURFACES BY REFLECTOMETRIC METHOD

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 10, Oct 83 pp 17-20

SOLODUKHO, F. M.

[Abstract] The feasibility of measuring the roughness of ultrasmooth surfaces by the reflectometric method is examined on the basis of two theories, the classical scalar theory of scattering and the vector theory of reflection for electromagnetic waves. The scalar theory treats the surface statistically only. The vector theory also accounts for the physical nature of electromagnetic radiation, including the polarization state of incident and reflected waves, as well as the optical properties of the surface material and the interaction of electromagnetic waves with free electrons at the boundary between two media. The mathematical relations for reflectometry are derived from the solution to the diffraction problem in the Kirchhoff approximation, with appropriate boundary conditions in a hemispherical space, assuming that surface roughness causes only redistribution of the light flux without influencing its absorption. The vector theory is not yet suitable for engineering applications, because it has not yet been satisfactorily confirmed by experimental data, even though it describes the angular distribution of relfected light more accurately than does the scalar theory. Using the scalar theory, therefore, requires a statistical analysis of ultrasmooth surfaces and determining the roughness distribution function as well as correlation function. One optical instrument used for this purpose is a multibeam interferometer forming fringes of the same chromatic order and using a xenon lamp as source of white light, a Fizeau interferometer, a spectrograph, a television camera with slow scanning, and a minicalculator. Another instrument used for this purpose is an optical feeler gauge (Hewlett-Packard Talystep 5480B) with digital readout. Measurements made on specimens of many materials (quartz, silicon carbide, copper, nickel, titanium, molybdenum, aluminum, Invar, Monel metal, rock salt, stainless steel) with superfine surface finish indicate a normal distribution but nongaussian correlation of asperity height. All ways to determine the standard deviation of asperity heights and the correlation interval as well as the spectral density function and the correlation function are still burdened with appreciable error. Determining the standard deviation of asperity heights from the ratio of light flux specularly reflected to total light flux reflected into a hemispherical space or from the ratio of normally incident light reflected diffusely in all directions except normally back to total reflected light flux is nevertheless quite practicable. Determining the spectral density function and the correlation function from the scattering indicatrix is also preferable to conventional use of profilograms or interferograms, on account of faster and contactless measurement. Determining the standard deviation of asperity heights from the ratio of specularly reflected light fluxes striking the test surface at different incidence angles or from the ratio of the reflection coefficients for specularly reflected light of two different wavelengths is not sufficiently sensitive for ultrasmooth surfaces. Determining the standard deviation of

asperity heights from the ratio of specularly reflected light fluxes striking the test surface at different incidence angles or from the ratio of the reflection coefficients for specularly reflected light of two different wavelengths is not sufficiently sensitive for ultrasmooth surfaces. Determining the standard deviation of asperity heights and the correlation interval from measurement of normally incident light fluxes reflected into different solid angles or from two ratios of light fluxes relfected into small solid angles and determining the standard deviation of asperity heights from the ratio of light fluxes reflected by the test surface and a reference surface respectively, at different angles or from the ratio of light fluxes specularly reflected from the test surface and a reference surface respectively is not yet feasible because of the unavailability of means of certifying an ultrasmooth reference specimen with sufficient precision. Figures 3, table 1, references 30: 6 Russian, 24 Western.
[102-2415]

UDC 62-755

BALANCING OF FLEXIBLE ROTORS WITH SIMULTANEOUS PRECISE DETERMINATION OF INFLUENCING FACTORS

Moscow MASHINOVEDENIYE in Russian No 1, Jan-Feb 84
(manuscript received 22 Jul 82, after completion 10 May 83) pp 26-32

RYZHIK, P. V. and FRIDMAN, V. M., Leningrad

[Abstract] An algorithm of balancing is proposed for a flexible horizontal rotor in isotropic bearings at several speeds, nominal operating speed as well as near critical ones, such balancing being nowadays done with the aid of a computer. It is based on the equations of flexural vibrations of a rotating shaft, assuming that the latter has a variable circular cross section and rests in two linear isotropic elastoviscous and bearings. These equations are formulated in two rectangular systems of coordinates, one stationary and one rotating with the shaft, their common origin at the center of one (left-hand) bearing. According to the method of solution of the resulting system of algebraic equations for the mass coefficients, there are two groups of balancing methods possible. Either all these equations are satisfied simultaneously so that rotor vibrations at all selected frequencies cease, or this system of equations is solved iteratively so that balancing proceeds successively at each selected frequency alone. Any balancing operation occurs in three stages: 1) first startup for measurement of vibrations due to static unbalance; 2) subsequent startups for determination of the dynamic characteristics and particularly the influencing factors; 3) improvement of the vibratory state through selection and location of slugs with intervening startups for verification. Simultaneous balancing is preferable to sequential balancing, because it requires fewer startups. The proposed algorithm of such balancing utilizes a priori information about influencing factors, which significantly reduces the intensity of vibrations

during the balancing process. This algorithm has been programmed for a computer at the Leningrad Economic Planning Department of "Elektrosila" Scientific-Industrial Association. References 7: 6 Russian, 1 Western. [110-2415]

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